

*Ex-1*  
exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane; and

after exposing the first conductive layer, forming a second conductive layer on the first conductive layer.

#### REMARKS

Claims 4, 76, 77 and 81-85 are currently pending in the present patent application. In an Office Action mailed 5 June 2002, the Examiner rejected all pending claims under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,201,276 B1 to Agarwal *et al.* ("Agarwal").

Applicant's invention exposes a conductive layer to an oxygen-inhibiting material prior to the formation of the another layer or layers on the conductive layer to substantially reduce the association of oxygen with the conductive layer during formation of the other layer or layers. By reducing the amount of oxygen associated with the conductive layer, the electrical characteristics of a semiconductor device including the conductive layer are improved, as will be discussed in more detail below with reference to the disclosed embodiments of the invention. In order to help the Examiner appreciate certain distinctions between the pending claims and the subject matter of the applied reference, the disclosed embodiments of the invention will now be discussed in comparison to the applied reference. Specific distinctions between the pending claims and the applied references will be discussed after the discussion of the disclosed embodiments and the applied reference. This discussion of the differences between the disclosed embodiments and applied reference does not define the scope or interpretation of any of the claims.

One embodiment of the present invention is discussed with reference to Figures 7-10 in which an interposing layer 52 such as a tungsten nitride layer 52 is formed between a conductive plug 46 formed in a via 44 and a conductive line material 48 formed in a trench or container 50. The tungsten nitride layer 52 enhances the electrical contact between the line material and the plug, promotes adhesion of the line material within the container 50, prevents or slows the diffusion of materials across the tungsten nitride layer boundary, or serves some other

purpose. As previously described, the tungsten nitride layer 52 may associate with oxygen after it is formed and subsequent thermal processes may result in the formation of an oxide layer 54 formed between the tungsten nitride layer 52 and the line material 48. Because the oxide layer 54 is an insulator, this layer will adversely affect the electrical connection between the line material 48 and the plug 46. By exposing the tungsten nitride layer 52 to an oxygen-inhibiting agent or a reducing atmosphere prior to formation of the line material 48, the thickness of the oxide layer 54 is reduced to a thickness of less than 10 angstroms or entirely eliminated as illustrated respectively in Figures 9 and 10. In this way, the conductive tungsten nitride layer 52 is exposed to an oxygen-inhibiting agent or reducing atmosphere prior to the line material 48 being formed on the conductive tungsten nitride layer to thereby reduce an ability of the conductive tungsten nitride layer to associate with oxygen. As described in the specification, the tungsten nitride layer 52 or other conductive layer may be treated in a plasma such as an N<sub>2</sub> and H<sub>2</sub> plasma, an NH<sub>3</sub> plasma, or an N<sub>2</sub> plasma. See page 6, lines 13-30 and page 7, lines 1-19. Furthermore, the conductive layer may be treated in a nitrogen-free gas, such as a plasma treatment including H<sub>2</sub>, or may be treated with other materials such as diborane B<sub>2</sub>H<sub>6</sub>, phosphine PH<sub>3</sub>, methylsilane CH<sub>3</sub>SiH<sub>3</sub>, hexamethyldisilane (CH<sub>3</sub>)<sub>3</sub>Si-Si(CH<sub>3</sub>)<sub>3</sub>, hexamethyldisilazane HMDS, carbon tetrafluoride CF<sub>4</sub>, CHF<sub>3</sub>, HCL, boron trichloride BCl<sub>3</sub>, and silane SiH<sub>4</sub>, and any combinations of these materials, as described on page 7, lines 25-30, page 8, lines 1-16, and page 9, lines 1-12.

The Agarwal patent discloses a method for passivating a dielectric layer 16 to form a passivation layer 18a thereon as shown in Figures 1A and 1B. The passivation layer 18a can be formed by annealing the dielectric layer 16 in a reactive environment composed of various gaseous materials, such as nitrogen, hydrogen, ammonia, hydrazine, monomethyl hydrazine, H<sub>2</sub> and N<sub>2</sub>, carbon tetrafluoride, CHF<sub>3</sub>, HCL, boron trichloride, and mixtures thereof, as described in Column 4, lines 49-62. The exposure of the dielectric layer 16 to the reactive atmosphere forms the passivation layer 18a to limit or stop oxygen, carbon, or other species from transporting between the dielectric layer and an upper electrode.

In another embodiment shown in Figures 2A and 2B of Agarwal, an electrically conductive lower electrode 14 is exposed to such a reactive environment to form a passivation layer 18b thereon and an insulating dielectric layer 16 then formed on the passivation layer 18b.

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The passivation layers 18a, 18b are electrically insulating layers, which is not a concern in Agarwal since a dielectric layer, which is another electrically insulating layer, is being formed on the passivation layer in either case. Thus, in Agarwal, when the conductive lower electrode 14 is passivated the nonconductive passivation layer 18b is formed on the lower electrode, which is fine since the dielectric layer 16 is then formed on the passivation layer. If another conductive layer was to be formed on the conductive lower electrode 14, however, the passivation layer 18b would inhibit electrical connection between the two conductive layers and form an unwanted capacitor corresponding to the electrode 14, layer 18b, and the other conductive layer. The passivation layer 18b would need to be removed to allow proper electrical connection between the electrode 14 and other conductive layer.

Amended claim 4 recites a method of passivating a conductive material. The method includes providing the conductive material which has an ability to associate with oxygen. The conductive material is directly exposed to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane. Notwithstanding the Examiner's assertion, Agarwal neither discloses nor suggests exposing the conductive material to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane. No such disclosure is made in Agarwal, column 4, lines 49-62 or in column 5, lines 61-66 as cited by the Examiner, or anywhere else in the Agarwal patent. While Agarwal discloses exposing a conductive layer to certain recited compounds, none of the materials recited in claim 4 is set forth in the Agarwal patent. To be an anticipatory reference under any section of 35 U.S.C. § 102, a reference must disclose each and every element recited in a claim, and Agarwal simply does not disclose the recited materials set forth in amended claim 4. Agarwal discloses the recited compounds "and the like," column 4, lines 57-58, but such a rote or "boiler plate" recitation does not anticipate every possible compound and thereby allow the reference to be used as anticipatory reference under Section 102. Moreover, such a rote recitation does not mean the reference inherently discloses the recited compounds since inherency requires that something necessarily follow from the disclosure in the reference and not merely that it "may" follow. The combination of elements recited in amended claim 4 is not anticipated nor obvious in view of Agarwal, and amended claim 4 is thus allowable.

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Amended claim 76 recites a method of passivating a conductive layer including providing a tungsten nitride layer and providing a polysilicon layer on the tungsten nitride layer. The tungsten nitride layer is exposed to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane. Once again, Agarwal neither discloses nor suggests exposing the tungsten nitride layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane. Therefore, the combination of elements recited in amended claim 76 is allowable.

Amended claim 81 recites a method of passivating a conductive layer. The method includes providing a first conductive plug, providing a first conductive layer on the plug, and exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane. After exposing the first conductive layer, a second conductive layer is formed on the first conductive layer. Agarwal neither discloses nor suggests exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane. Moreover, Agarwal neither discloses nor suggests forming a second conductive layer on the first conductive layer. The combination of elements recited in amended claim 81 is therefore allowable.

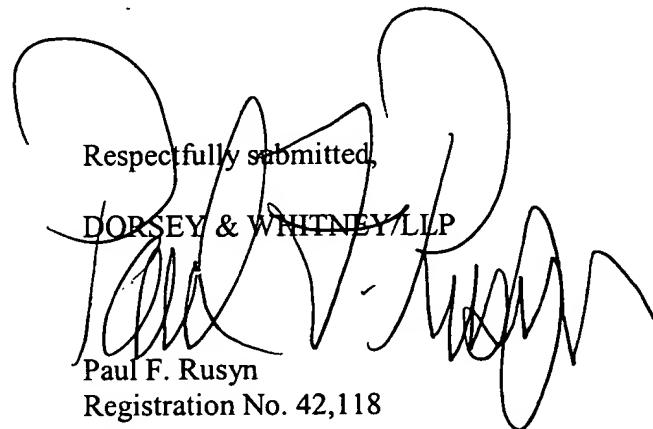
The claims dependent on the independent claims are allowable for the same reasons as the independent claims, and because of the additional limitations added by the dependent claims.

The specification has been amended to include a patent number corresponding to an application number set forth in the specification. This amendment adds no new matter.

All pending claims are in condition for allowance, and favorable consideration and a Notice of Allowance are respectfully requested. The Examiner is requested to contact the undersigned at the number listed below for a telephone interview if, upon consideration of this amendment, the Examiner determines any pending claims are not in condition for allowance.

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Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "Version with Markings to Show Changes Made".

  
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PFR:asw

Enclosures:

Postcard

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Paragraph beginning at line 4 of page 8 has been amended as follows:

Still other gases include diborane (B<sub>2</sub>H<sub>6</sub>); phosphine (PH<sub>3</sub>); and carbon-silicon compounds such as methylsilane (CH<sub>3</sub>SiH<sub>3</sub>), and hexamethyldisilane (CH<sub>3</sub>)<sub>3</sub>Si-Si(CH<sub>3</sub>)<sub>3</sub>; and hexamethyldisilazane (HMDS). Additional alternate embodiments of the current invention use hydrazine (N<sub>2</sub>H<sub>4</sub>), monomethylhydrazine, carbon tetrafluoride (CF<sub>4</sub>), CHF<sub>3</sub>, HCl, and boron trichloride (BCl<sub>3</sub>), which are also useful in passivating dielectrics, as addressed in copending application 09/114,847, now issued as U.S. Patent No. 6,201,276 B1. Also included are mixtures of any of the gases or types of gases described above. Exemplary non-plasma process parameters using these other gases include a flow rate of about 2 sccm to about 400 sccm for these gases; a flow rate of about 50 sccm to about 100 sccm for an inert carrier gas such as He or Ar; a temperature ranging from about 150 to about 600 degrees Celsius, a pressure ranging from about 50 millitorr to about 1 atmosphere (760 torr); and a process time ranging from about 50 to about 500 seconds. Again, one skilled in the art is aware that these parameters can be altered to achieve the same or a similar process.

In the Claims:

4. (Thrice Amended) A method of passivating a conductive material, comprising:

providing said conductive material, wherein said conductive material has an ability to associate with oxygen; and

directly exposing said conductive material to a [selection] material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane[ HCL, boron trichloride, and combinations thereof to reduce the ability of the conductive material to associate with oxygen prior to forming another conductive material on the conductive material].

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76. (Twice Amended) A method of passivating a conductive layer, comprising:

providing a tungsten nitride layer;  
providing a polysilicon layer on the tungsten nitride layer; and  
exposing the tungsten nitride layer to a [selection] material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane[, HCL, boron trichloride, and combinations thereof to passivate the tungsten nitride layer prior to formation of the polysilicon layer on the tungsten nitride layer].

81. (Twice Amended) A method of passivating a conductive layer, comprising:

providing a first conductive plug;  
providing a first conductive layer on the plug;  
exposing the first conductive layer to a [selection] material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane[, HCL, boron trichloride, and combinations thereof to passivate the first conductive layer]; and

after exposing the first conductive layer, forming a second conductive layer on the first conductive layer.